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PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improvements in Lighting Fixtures

We, RAMBUSCH DECORATING COMPANY, a corporation organized under the laws of the State of New York, of 2, West 45th Street, in the City, County and State of New York, United States of America, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The present invention relates to lighting fixtures, and is more particularly directed toward lighting fixtures intended to be mounted in or on the ceiling and for producing controlled lighting in restricted working areas below the fixtures.

The present invention contemplates lighting fixtures in which the upward component of light produced by the light source (with or without an upwardly acting reflector below the source) is directed downwardly by reflectors of such contour as to produce a controlled symmetrical distribution of light. The fixtures contemplated by the present invention employ reflectors with as high a degree of specular reflection as possible in commercial materials, and the disposition of the reflecting surfaces and light source are such that the desired spread and distribution of light is available. These reflectors and the light source are suitably screened so that direct observation of surfaces of substantial brightness is avoided. The source of the illumination may for practical purposes be completely concealed at ordinary angles of observation.

Where one desires to accurately control and distribute light from small sources, such as the tungsten lamp filament, by reflection, the reflecting surfaces must have proper focal relations with the light source for otherwise the reflected rays scatter into uncontrollable angles. The parabolic reflector, which has the ability to collect light rays from a concentrated source at the focus and project them in a beam of parallel rays, is suitable for projection work, but is unsuited for illuminating extensive working areas, because it is impossible in a fixture of reasonable size to cover an extended working area. The ellipse has the well-known characteristic of collecting light originating at one focus and reflecting it convergently toward the other focus. It continues divergently and may be made to cover an area substantially greater than the area of the reflector itself.

With light sources such as the pendent, bowl silvered lamp, or the incandescent lamp bulb with specular spherical reflector underneath, practically the entire output of the lamp is directed above the horizontal and at substantial angles from zenith so that nearly all the lumen output is within the zone from 90 to 150 degrees above nadir. The available light is therefore substantially all concentrated into a 60 degree zone immediately above the horizontal. The present invention contemplates the provision of a luminair having reflectors of elliptical contour (or a very close approximation thereto) adapted to intercept light in this region and reflect it downwardly at such angles as to produce downwardly directed light of adequate divergence to cover the desired working area. Where no light from the source goes directly to the working area below the luminair the spread and distribution is under the control of the reflectors, without admixture of direct light. By proper selection of the location of the conjugate foci of the reflecting areas and the light output handled by them the spread of the light may be controlled to place the light on the desired area with either a very even intensity of illumination, or marked asymmetry.

According to the present invention we provide a luminair comprising a light source, a downwardly acting specular reflector symmetrical on opposite sides of a central vertical axis through the source and accepting substantially all the light emitted by the source in an axial plane and above a horizontal plane near the level of the source, the reflector being composed of angularly contiguous reflecting zones of elliptical profile in said axial plane, the said zones having a common focal point at the center of the light source and coincident conjugate focal points in said axial plane and uniformly

displaced on opposite sides of said central vertical axis, the axes of the ellipses in which zones are formed being shorter as the zones approach the central axis of the luminair for the purposes described.

The accompanying drawings show, for purposes of illustrating the present invention, several of the many embodiments in which the invention may take form, it being understood that the drawings are illustrative of the invention rather than limiting the same.

In these drawings:

Figure 1 is a diagram illustrating the functioning of a series of elliptical reflectors with fixed foci and varying eccentricities, and also the functioning of angularly contiguous segments of such reflectors forming a single stepped reflector;

Figure 2 is a diagrammatic view illustrating the distribution of light from a long light source and two sets of rectilinear elliptical reflectors of the type shown in Figure 1, placed on opposite sides of a vertical axis;

Figure 3 is a view illustrating the illumination of a working area by an annular luminair;

Figure 4 shows a photometric curve of an annular luminair and an illumination intensity curve on a working area at a distance;

Figure 5 is a diagram illustrating reflector action with various locations of conjugate foci;

Figure 6 is a vertical cross sectional view through an annular luminair such as employed in obtaining the curves of Figure 4;

Figure 7 is an inverted plan view of the luminair of Figure 6 with parts in section on the line 7—7 to show interior construction; and

Figures 8 to 10 illustrate modified forms of construction.

In Figure 1 the light center as well as one of the foci of a series of ellipses is indicated by the letter F. The horizontal line 10 extending through this focus and the oblique line 11 at an angle of approximately 60° to the horizontal represent the limiting rays to the left of a vertical axis V—V which, it is contemplated, are to be intercepted by the reflector to the left of this vertical axis and reflected downwardly through the conjugate focus F^1. This fixes the location of the major and minor axes 12 and *12a* as indicated. The lengths of these axes and the eccentricities of the ellipses will vary. For purposes of illustration the conjugate focus F^1 is located so that the highest reflected ray from the outer edge 12^1 of the reflector form is at an angle of 30° with the vertical, and furthermore F^1 is offset from line V—V a distance of about 65% of the distance from F to 12^1.

With the foci F and F^1 at assumed positions an indefinite number of ellipses may be drawn which intersect the lines 10 and 11 and in each case the reflector profile conforming to the elliptical contour between lines 10 and 11 will intercept the same amount of light. In the drawing a series of elliptical arcs are drawn. The largest starting at 12^1 and having the greatest eccentricity is lettered A. The smaller and less eccentric arcs are lettered B, C and D. It is obvious that more or less than four ellipses may be employed and at an entirely different spacing. While a reflector form made according to any one of these ellipses will concentrate all the reflected light in the zone under consideration at the point F^1, it appears from the drawing that the different elliptical reflector forms A, B, C, D, give different distributions of light; for example, a reflector A would condense the light into the upper angle A^1 (which is less than the divergence of the original rays) and diverge it through the lower angle A^1, and the light would fall on the working plane WP between aa and aa. The reflector B would direct the light through the smaller angle indicated at B^1 and it would fall on the portion of the working plane WP between bb and bb. Similarly the reflectors C and D would concentrate the light in the regions indicated by the angles C^1 and D^1, respectively, and the light would fall on the working plane between cc and cc and dd and dd, respectively. The larger reflector A will, it is apparent, give a distribution which will cover an area greatly different from the area which can be reached by light reflected by reflector D. In each case the beam projected by the single reflector has a narrow distribution of light with non-uniform intensity throughout the width of the beam and tends to concentrate the light into a bright spot when it falls on the working plane. If therefore any single reflector form were used such as A, B, C or D, one would obtain an entirely different distribution of light on the working plane.

Figure 1 illustrates the effect of employing a narrow segment only of each of the ellipses A, B, C and D and arranging these segments as indicated at *a*, *b*, *c*, *d*, so that they occupy angularly contiguous zones about focus F and therefore will in the aggregate intercept the same amount of light as any one of the wider angled elliptical segments A, B, C or D. The angles selected in the drawing are arbitrary. In actual design the contour

of the stepped reflector will be such as to give the best distribution from the source to be used. The segment a of the ellipse A sends a beam of light indicated at a^1, whose extreme ray below the conjugate focus F^1 has the same inclination to the right of the vertical as did the corresponding light ray from the reflector A. The small reflector d produces a beam of light d^1 whose extreme ray below F^1 has the same inclination to the left of the vertical as did the corresponding ray produced by the reflector D. The small elliptical reflectors b and c, taken out of ellipses B and C, produce narrow light beams indicated at b^1 and c^1. It will be noted from the drawing that the reflector a produces a beam a^1 less convergent than the light incident on it and thus widens the distribution of the lumen output in the zone of the incident light, and that the reflector d produces a much more convergent beam d^1 than the light rays incident on it and thus condenses the lumen output in this zone.

By breaking up the reflector form into the four subordinate elliptical reflectors with intermediate inactive regions e, f and g, four zones of illumination a^1, b^1, c^1 and d^1, and three intermediate theoretically unlighted zones e^1, f^1 and g^1 are produced. The divergence to the left of the vertical v—v through the focus F^1 available in the smaller ellipse D is preserved and at the same time the divergence to the right of the vertical v—v by the larger ellipse A is preserved so that the overall divergence of the output of light from the stepped reflector is much greater than available with any single reflector of elliptical contour and the same foci and major axis. The zones e^1, f^1 and g^1 are indicated by light cross hatching in Figure 1 between the lighted zones d^1 and c^1, c^1 and b^1, and b^1 and a^1, respectively. They are brought about by reason of the fact that no specularly reflected light from the point source is emitted downwardly in the angles e^1, f^1, g^1 of Figure 1.

The inactive surface f is directly above the conjugate focus F^1 and hence no specularly reflected light is emitted vertically downward. If there were an active elliptical surface directly above the conjugate focus F^1 it would project light rays parallel with the axis and tending to produce a region of excessive brightness near the center of the working area.

It will be noted from Figure 1 that the position of the conjugate focus F^1 is such that the divergence of light on each side of the vertical v—v is approximately the same. A shift of the focus F^1 to the right or to the left with corresponding change in the reflector contour will disturb this approximate balance and build up the amount of light diverging to one side of the vertical at the expense of light diverging to the other side of the vertical.

The above discussion is based upon light rays from a point source and perfect specular reflection with reflectors perpendicular to the plane of the paper. In practice the light source instead of being a point at F may be on opposite sides of F, as indicated at 13 and 14, and rays such as 15, 16, 17 and 18 may converge on the reflector and be reflected as indicated at 15^1, 16^1, 17^1 and 18^1, respectively, but generally toward F^1. In practice the reflector is not a perfect specular reflector and the glass used in the incandescent lamp bulb may be frosted. All this will act to cause divergence of the direct light rays greater than the theoretical and spread the light over into the intermediate or theoretically dark zones. Where downwardly emitted light from the source is reflected upwardly by a cylindrical reflector 19 concentric with the focus F, there will be further divergence of the light rays on account of the eccentric position of the filament. As a result the intensity of illumination on a working plane with a rectilinear source and reflector both perpendicular to the plane of the paper may partake of the character illustrated by the curve 20. The high intensity in the left portion of the curve is brought about by the relatively large width of the zone d and the concentrating action of the corresponding portion of the reflector.

Figure 2 illustrates the light output where a similar reflecting system has been placed on the opposite side of the vertical axis V—V to distribute light from a conjugate focus F^{11} to the right of the vertical axis V—V. The distribution of light from the two conjugate foci F^1 and F^{11} on the working plane WP is illustrated in Figure 2 and the same reference letters are employed as in Figure 1 to represent the distribution of light from focus F^1. The distribution of light from focus F^{11} is indicated by small letters with double primes and the distribution over the working plane between aa^1 and dd^1 instead of between aa and dd. The curve 20 of Figure 1 is reproduced in Figure 2. A dotted curve 20^1 reversed with respect to curve 20 illustrates the effect of the second similar stepped reflector above F^{11}, and a heavy curve 20^{11} illustrates the intensity of illumination to be had on a working plane remote enough to have allowed the two beams to mix. With this arrangement of rectilinear source and reflectors it is possible to secure a reasonably even illumination over a central area

and a higher illumination on each side of the central area. This type of distribution is typically what one would use to build up higher intensities on opposite sides of an aisle. By properly selecting the angular extent of the reflecting zones, the divergences of the beams produced, the location of the conjugate foci, and the mounting height above the working plane it is possible to secure various distributions of light over the working plane which have low intensity in the center area and higher intensities in side areas.

Where the reflector contour of Figure 1 is used in an annular reflector with an ordinary incandescent lamp the zones illustrated in Figure 2 may be deemed to be revolving about the vertical axis V—V. This is illustrated in Figure 3, where the lines are drawn from the foci F^1 and F^{11} the same as in Figure 2. The filament is necessarily displaced from the center and therefore eccentric with respect to the center of a spherical reflector. With the bowl silvered lamp the reflecting surface is ordinarily not concentric about the light center and the reflected rays are therefore further scattered. This departure of the light rays from the ideal of the drawing will cause additional divergence of the light beams.

Instead of the boundaries of the elliptical areas being rectilinear as contemplated in Figure 2, they are annular, and the lumen output from a source intercepted by an annular zone of unit angular width is a function of the angular position of the zone relative to the horizontal; for example, the lumen factor for a 10° zone in the region of reflector *a* (which is in the 95° zone above nadir) is 1.090, for the outer part of reflector *d* (which is in the 125° zone above nadir) is .897, and for the inner part of reflector *d* (which is in the 155° zone above nadir) is .463. As a result of the variation of lumen output of the source in the vertical angular region under consideration, the concentrating action of the inner reflector *d*, the spreading action of the outer reflector *a*, the variation in area of annular regions on the working plane of equal width, the overlapping of the beams and the scattering of light arising from diffuse reflection, diffuse transmission, size of light source and eccentricity of the spherical, or nearly spherical reflector, the resultant illumination on the working plane may be very even.

This evenness of illumination is illustrated by the curve 21 in Figure 3, the spread being about 30° each side of the vertical.

Figure 4 shows the photometric curve of an annular luminair with a stepped elliptical reflector and a 150 watt bowl-silvered lamp. The lamp output is illustrated at 22 and the luminair output at 23. The curve 24 shows the intensity of illumination on a working area 10 feet below the luminair.

In Figure 5 it is assumed that the light source is at F and that a series of reflectors of elliptical contour with one focus at F extend from the point 25 on the horizontal plane through F upwardly toward zenith. The vertical lines marked 50%, 60%, 70% and 80% show the loci of conjugate focal offsets of the named percentage from the vertical V—V to the point 25. The sloping lines 26, 27 and 28 marked "45° Max. above nadir", "30° Max. above nadir" and "20° Max. above nadir", respectively illustrate reflected rays at these angles from the point 25. These sloping and vertical lines are for purposes of illustration. At whatever percentage offset is selected and angle of maximum above nadir selected a point may be located where the lines intersect which forms a conjugate focus for an ellipse through the point 25, and for a series of other smaller elliptical arcs similar to those illustrated at *b*, *c* and *d* in Figure 1.

To illustrate the discussion the limiting elliptical arcs have been drawn using conjugate foci corresponding with the 45° maximum and the 80% and 50% offsets, and from the 20° maximum and the 80% and 50% offsets. The area bounded by these elliptical arcs is indicated by slanted cross hatching. All other ellipses from point 25 and having their conjugate foci within the region under discussion will fall within the cross hatched area, and it is obvious that when a stepped reflector is used with the corresponding conjugate focus its steps will be below the corresponding elliptical arc which goes through the cross hatched area. As an indefinite number of such stepped elliptical contours might be drawn they are omitted for clearness.

As it is intended to use a companion ellipse on the opposite side of the vertical V—V and to have the light cross below the light source and mix so as to spread over the working area to the same extent on each side of the vertical, it is desirable as the next assumption in designing the reflector to assume a maximum angle above nadir of the downwardly slanting rays from the outer margin of the reflector which equals the maximum above nadir of the downwardly slanting rays from the region of the reflector near zenith.

In Figure 5 a number of dash lines slanting upwardly and to the right appear, and to these the reference charac-

ter 29 is generally applied. These lines are drawn through selected intersections of the sloping lines 26, 27 and 28 and the percentage offset lines, each such dash line being at the same angle to the vertical as the corresponding maximum angle of the ray reflected from the point 25. It will be seen that these lines generally go through a region near zenith and that the reflector may be terminated at such a point near the zenith so that in typical cases the bisector of the extreme reflected rays may be vertical. It will also be apparent from the drawings that it is possible to design elliptical reflectors giving a distribution of from 20° each side of the vertical to 45° each side of the vertical and maintain the conjugate focus at a reasonable distance below the light source.

In the actual design of luminairs employing the elliptical reflector with or without steps it will, of course, be understood that proper consideration must be given the permissible diameter and depth of the unit, the necessary cut off and screening angles, and the obstruction caused by the upwardly acting reflector, where one is used, or the obstruction caused by the opaque light source where such a source is employed.

A structural embodiment of an annular luminair is shown in Figures 6 and 7. A pendent lamp bulb 30 is carried by the socket 31 connected to a suitable outlet box 32. The outlet box 32 carries a suitable cone shaped member 33 which is secured in any suitable manner to a sheet metal reflector 34 having an aperture 42 to accommodate the lamp bulb. This reflector is a surface of revolution about the vertical axis through the source and has a plurality of zones 34*a*, 34*b*, 34*c* and 34*d* of elliptical contour with one focus F at the light source and conjugate foci indicated at F^1 and F^{11} and disposed in a circle indicated by the dot and dash arc 38, Figure 7. The intermediate or inactive areas 34*e*, 34*f*, and 34*g* are sufficiently steep to avoid intercepting direct light either on their surfaces or on the fillets which connect them with the active surfaces. The luminair is provided with an outer cylindrical screen extending downwardly from the periphery of the reflector and carrying a flat apertured plate 37 at approximately the level of the foci F^1 and F^{11}. As here shown the lamp bulb is received in a spherical reflector 38. This reflector, as well as an inner cylindrical screen 39 and a flat screening disk 40 are supported from the upper reflector 34 by slips 41 which pass up through the central opening 42 of the upper reflector. The luminair can be conveniently recessed in a ceiling 43 as indicated. The aperture formed between the disk 40 and the plate 37 is sufficiently large to provide a window to allow substantially all the desirable light from the reflector to escape in the controlled directions. The light may therefore pass downwardly without passing through a dust collecting medium. The disk and plate together with the cylindrical screens 36 and 39 will completely screen the light source and the reflector 34 from the eye of an observer outside the region where the intense rays are being transmitted. The inside surface of the screen 36 and the outside surface of the screen 39 may be coated any desired color and this will be brought out by the spilled light intercepted by these elements.

In Figure 8 the outlet box, reflector and support for the same are shown as in Figure 6 and the same reference characters applied. Here the reflector 34 and support 33 are recessed in the ceiling and the screening means is in the form of a translucent bowl 50 having outer diffusing side walls 51 and is held up by screws 52. It also has inner diffusing side walls 53 which extend up near the bulb at substantially the level of the light source so as to facilitate the removal of a bowl silvered lamp 30^1. An annular region 54 forms the window for transmission of reflected rays. This window may be clear crystal glass where the diffuser is of glass, or one may employ openings as illustrated at 55 in Figure 9 where a plastic diffuser is used. The centre may be flat as indicated at 56.

Figure 10 illustrates the use of a long light source such as a fluorescent lamp 60 below a reflecting trough 61 of stepped elliptical contour. As the vessel wall of the fluorescent lamp is opaque the downward component of light is delivered to the working plane by a reflector 62 of a contour to effect a distribution to supplement that from the upper reflector. It also acts as a screen when the luminair is viewed from the side.

It is obvious that the invention may be embodied in many forms and constructions within the scope of the claims and we wish it to be understood that the particular forms shown are but a few of the many forms. Various modifications and changes being possible, we do not otherwise limit ourselves in any way with respect thereto.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A luminair comprising a light source, a downwardly acting specular re-

flector symmetrical on opposite sides of a central vertical axis through the source and accepting substantially all the light emitted by the source in an axial plane and above a horizontal plane near the level of the source, the reflector being composed of angularly contiguous reflecting zones of elliptical profile in said axial plane, the said zones having a common focal point at the centre of the light source and coincident conjugate focal points in said axial plane and uniformly displaced on opposite sides of said central vertical axis, the axes of the ellipses in which zones are formed being shorter as the zones approach the central axis of the luminair for the purposes described.

2. The luminair claimed in claim 1, wherein the reflecting zones are separated by inactive zones there being inactive zones spaced from the axis the same distance as the conjugate foci so that no specularly reflected light is emitted parallel with the vertical axis.

3. The luminair claimed in claims 1 or 2, wherein the conjugate foci forming virtual light sources are spaced substantially below the horizontal plane through the source a distance greater than 50 per-cent. of the distance from the source to the corresponding opposite points from which the reflector starts and substantially less than the entire distance.

4. The luminair claimed in claim 3, having outer screening means extending from the conjugate focal region to the outside of the reflector form and inner screening means extending from the conjugate focal region to the said horizontal plane whereby the reflector form and source are screened at angles outside the spread of the controlled specularly reflected rays.

5. The luminair claimed in claims 1, 2 or 3, wherein the source is a substantial point source and the reflector is annular and its surface is generated by revolving around the center axis of said reflector a generatrix consisting of a multiplicity of elliptical lines all of which are elliptical arcs having common foci; one of said foci being placed in the said centre axis substantially in the plane of maximum diameter of the reflector, the conjugate foci being placed at a predetermined distance from said center axis, and in the generation of said reflector describing a circle with its center on said center axis and in a plane substantially spaced below the first of said foci.

6. The luminair claimed in claim 5, wherein the eccentricities of the ellipses are progressively less as the elements approach the vertical axis through the source.

7. The luminair claimed in claim 5, wherein the radius of the circle forming the locus for the conjugate foci is such that the bisectors of the limiting reflected rays are substantially vertical whereby the divergence of light from the virtual sources of said conjugate foci is substantially the same on opposite sides of the vertical.

8. The luminair claimed in claims 2 and 5 for illuminating a horizontal circular area to a substantially uniform intensity wherein the zones of reflected light converge at said conjugate foci and diverge therefrom with an overall divergence sufficient to cover said area to be lighted, and the zones of reflected light are separated by zones of comparative darkness, the zones of illumination produced on said area by the reflector to one side of the vertical axis substantially coinciding with the zones of said area which would be comparatively dark if receiving light only from the opposite side of the reflector.

9. The luminair claimed in claim 8, wherein the source is of substantial size so that the fringes of the areas receiving specularly reflected light also receive spilled and scattered reflected light.

10. The luminair claimed in claims 1 and 4, having a concentric reflector under the source and screens extending from adjacent the region containing said conjugate foci to the outer periphery of the concentric reflector so that no glare from the light source proper nor glaring specular reflection thereof will be visible when the fixture is viewed from points beyond the controlled light beam.

11. The luminair claimed in claims 1, 2, 3 or 4, wherein the source is rectilinear and the reflector is rectilinear with the loci of the conjugate foci parallel, below the source, and displaced equally on opposite sides of the vertical plane through the source.

12. The luminair substantially as shown and described.

Dated this 24th day of March, 1941.

For the Applicants,

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Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1942.

SHEET 1

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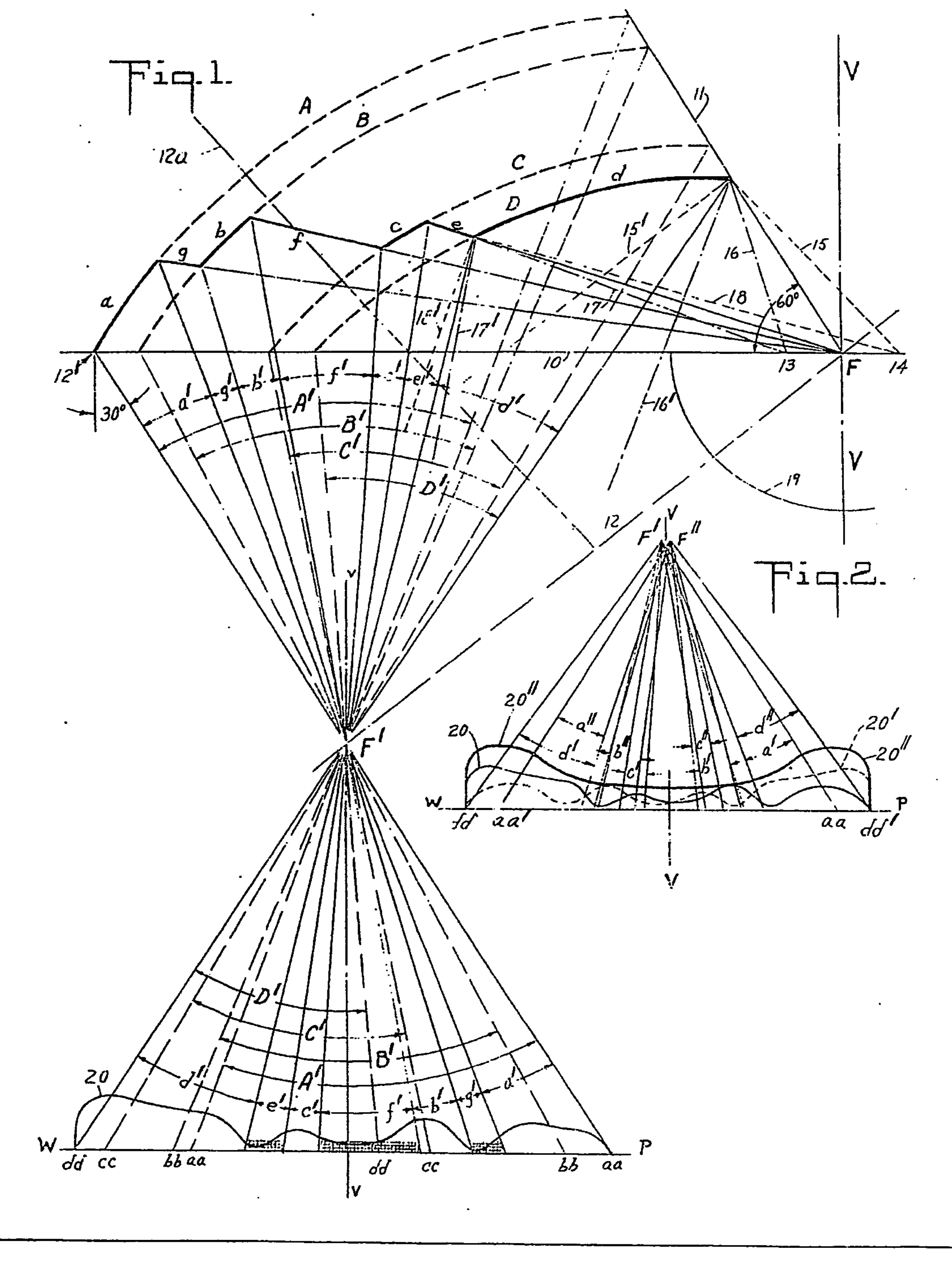

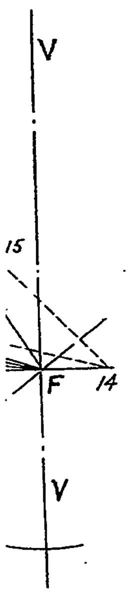

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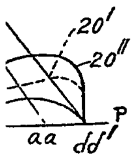

Fig.3.

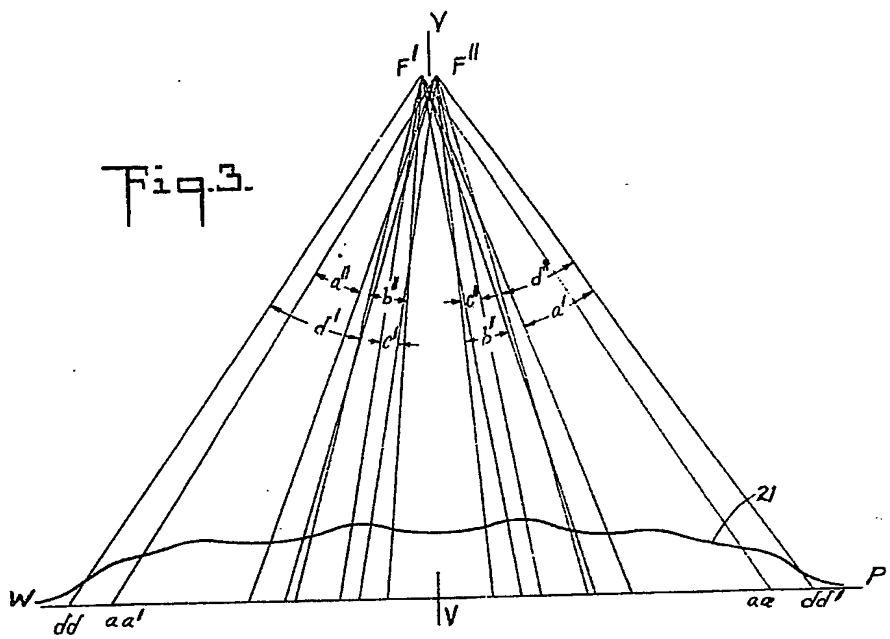

Fig.4.

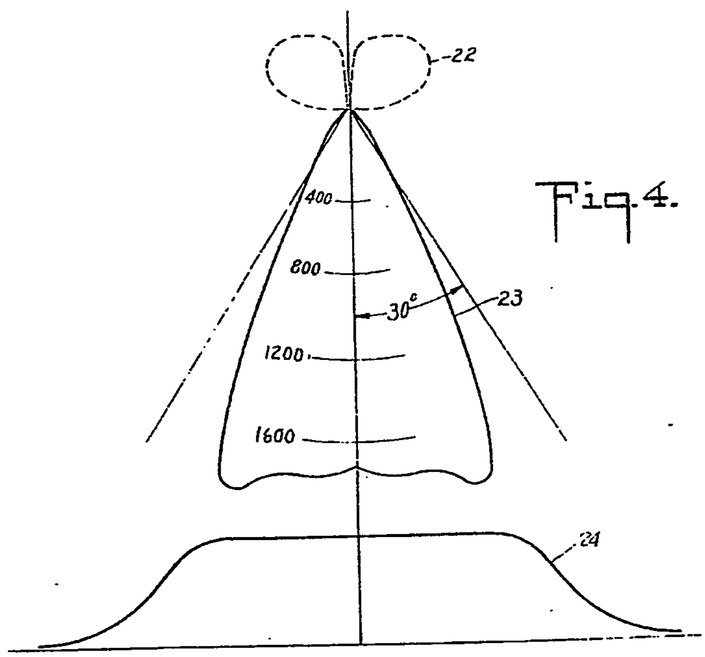

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Fig. 1.

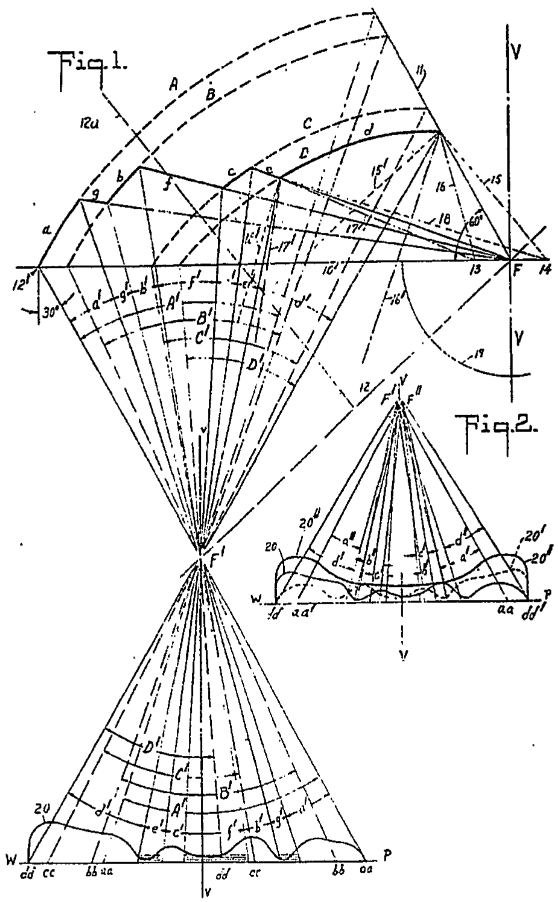

Fig. 2.

Fig. 3.

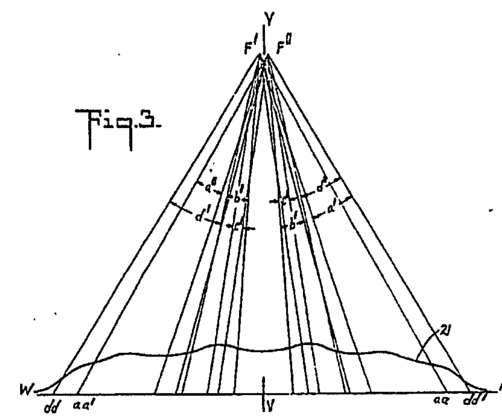

Fig. 4.

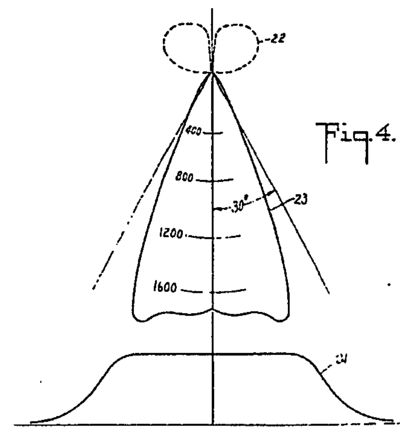

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Fig. 5.

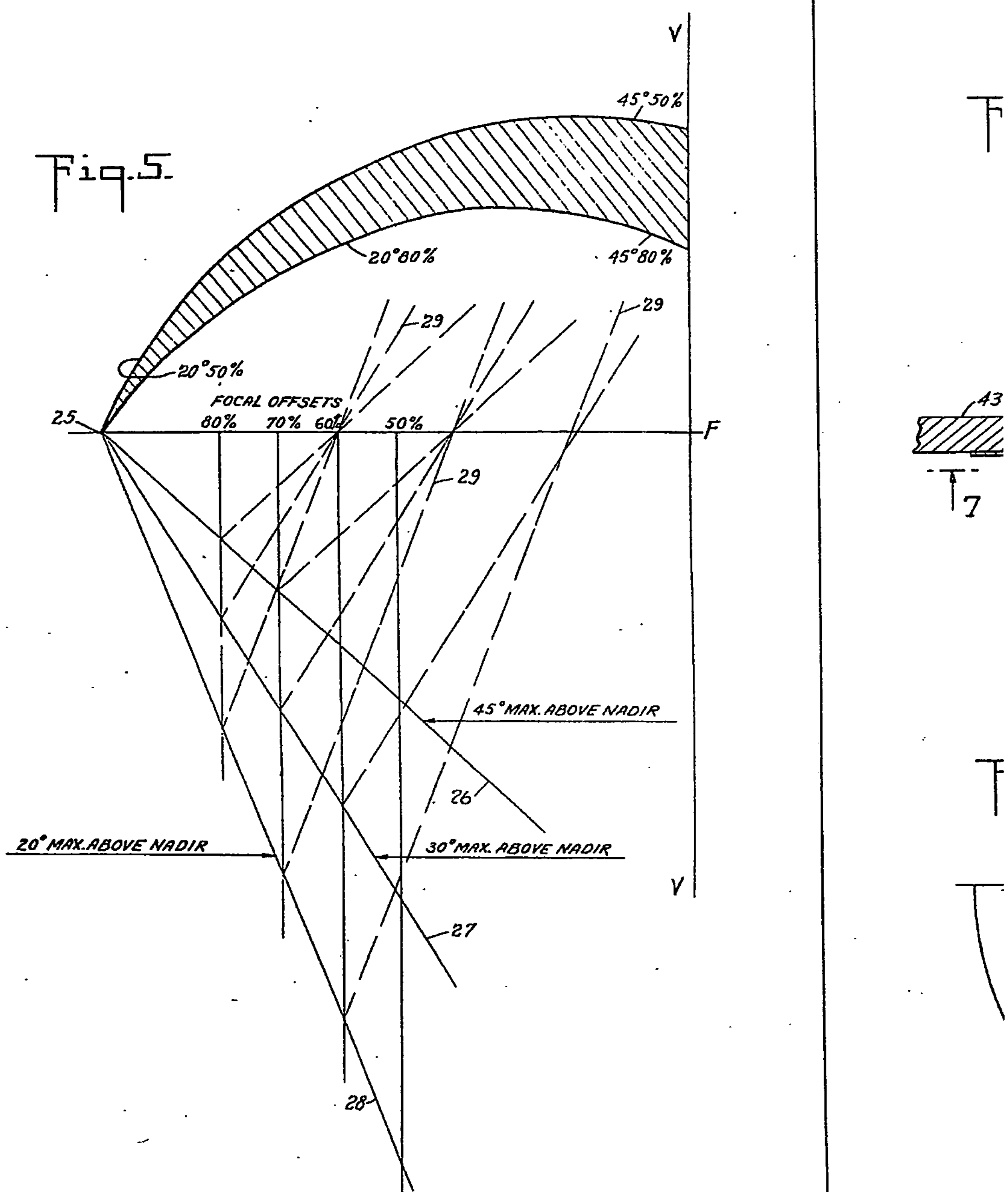

Fig.6.

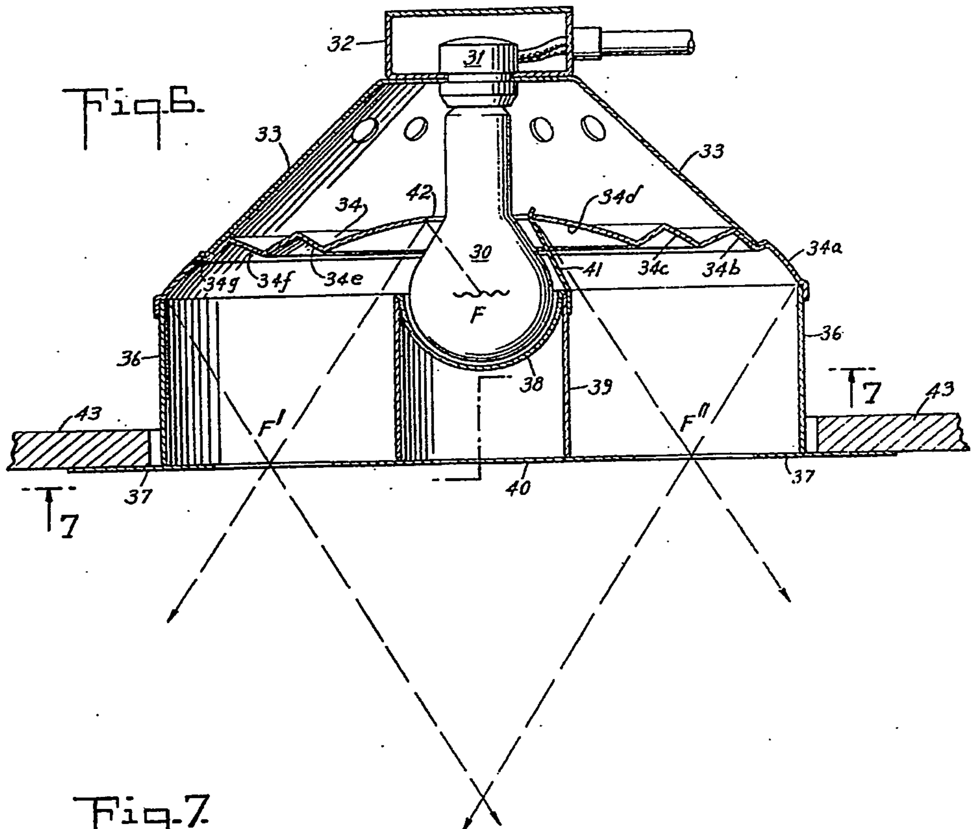
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Fig.7.

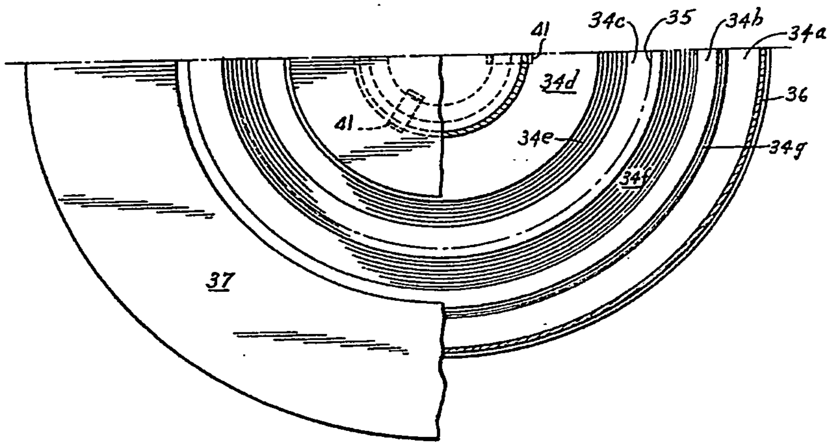
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Fig.5.

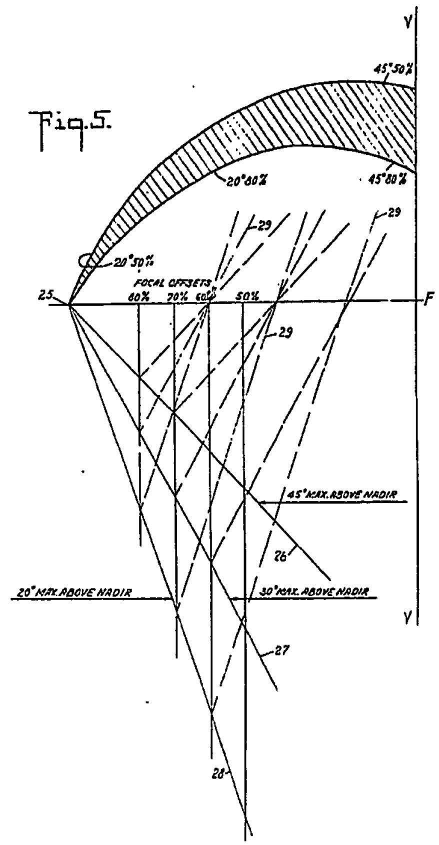

Fig.6.

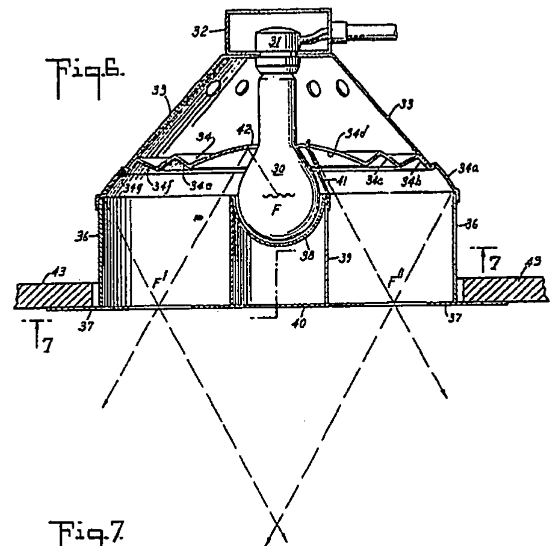

Fig.7.

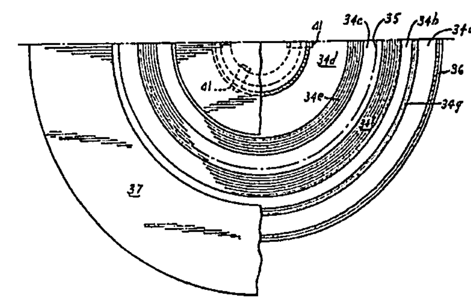

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Fig. 8.

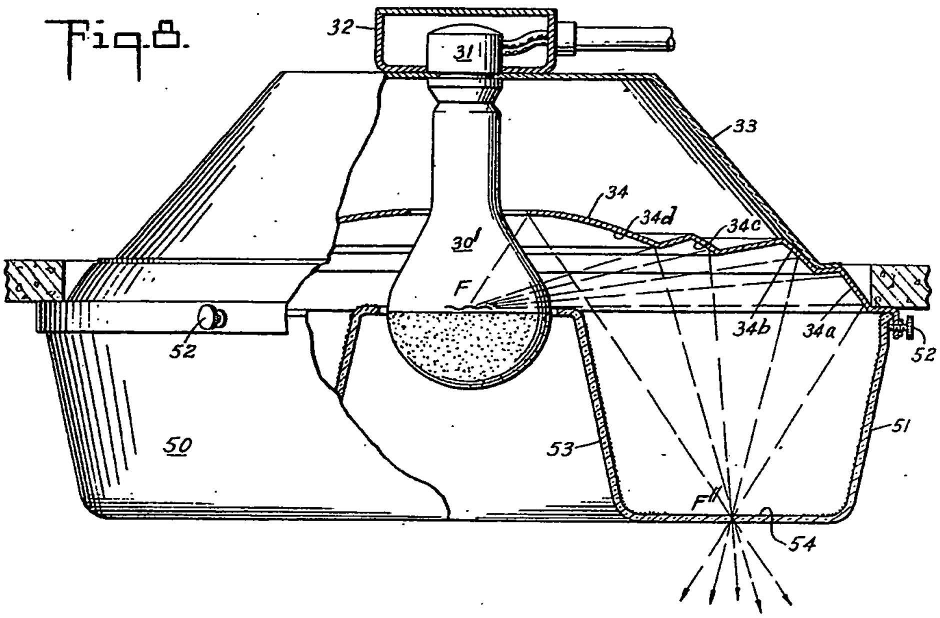


Fig. 10.

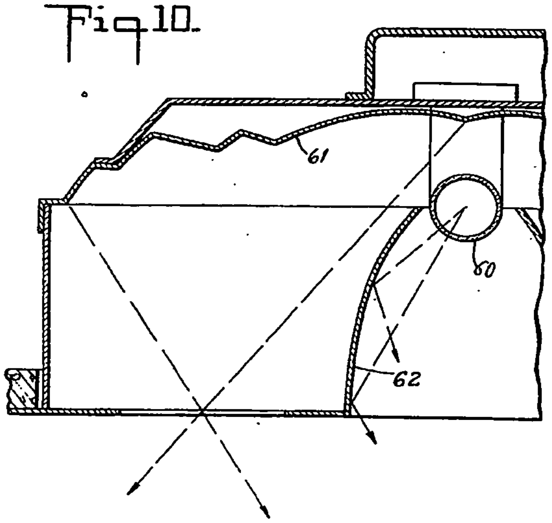
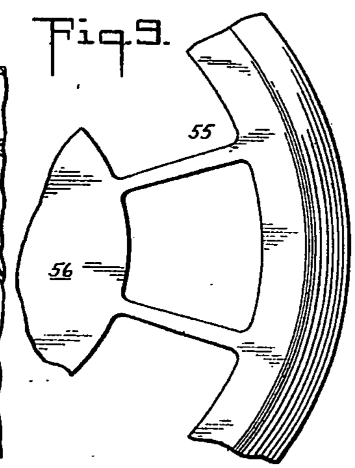


Fig. 9.



[This Drawing is a reproduction of the Original on a reduced scale.]

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